Osiris 10

10kW Grid Tie Wind Turbine User Manual

Ver 1. 2

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TO BE INSTALLED, MAINTAINED AND REPAIRED BY TRAINED PERSONNEL ONLY

Osiris Energy

1. Introduction

This manual contains important information concerning your Osiris 10 wind turbine. It is strongly recommended that you read and familiarise yourself with its contents before installing, operating or maintaining the turbine.

This manual gives a minimum standard that Osiris expects all installations to comply to. Installers are required to be MCS accredited and members of the REAL Assurance scheme and should ensure that installations comply with all requirements as part of these accreditations.

Installers are also required to keep abreast of current legislation and should ensure all installations comply with the most up to date legal requirements. Particular attention should be given to any changes in British Standards (eg BS7671 Wiring regulations), Energy Savings Trust recommendations or DNO connection requirements. Where changes in this legislation improve on the standards in this document the new guidance should be taken to overrule the information given in this manual.

The Osiris 10 turbine is a reliable, well engineered machine backed up with an impressive 5 year warranty. At Osiris we are confident that with proper installation and maintenance the turbine will run successfully and reliably for many years to come.

This document contains extracts from the EST CE72 Installing small wind-powered electricity generating systems best practice guide.

1.1. Technical Specification

Turbine Type	Downwind Horizontal Axis
Rated Power Output	10kW @ 9.5m/s
Annual power supplied	Approx 31,000 kWh at 6m/s, or greater in stronger winds
RPM	Variable. 120rpm at max generation
Cut In Wind Speed	3.0m/s
Maximum rated wind speed	50m/s
Blades	3 x carbon fiber reinforced glass fibre construction
Speed Control	Passive and automatic electrical pitch
Additional Safety Systems	Manual pitch control. Automatic Brake Resistors.
Rotor Diameter	9.7m
Head weight	900kG

2. System Description

The Osiris 10 is a downwind, horizontal axis, low RPM direct drive, permanent magnet wind turbine, designed to self regulates using a unique passive pitch system. With a peak rated output of 10kW at 9.5m/s the Osiris 10 is specifically designed for high reliability, low maintenance and automatic operation in adverse weather conditions.

Practical and perfect for supplying electricity to properties such as farms, large residences, offices, businesses and public buildings, an Osiris wind turbine allows you to generate your own green energy, effectively reducing your carbon footprint and publicly promoting your commitment to renewable energy.

2.1 Rotor and Blades

The rotor system consists of three molded fiber glass blades and carbon fiber blades. This method of production is very rare in the small turbine market and is usually only reserved for large MW size turbines. The blades are manufactured in house under a strict ISO 9001 quality system and are not bought in from an outside supplier. This ensures we have total quality control at all times and that we are confident that each blade is made to our exacting standards.

The blades convert the energy of the wind into rotational forces that drive the generator. The blades are carefully balanced in the factory before delivery to ensure smooth operation of the wind turbine and are supplied as a matched group. The blades are painted in impact resistant two-pack paint and have carbon fiber reinforced leading edges to ensure strength and durability

A passive blade pitch mechanism limits the maximum rotational speed of the rotor. The mechanism consists of 4 springs and mechanical linkages attaching these to the blade root. The pitch setting is factory set and the whole mechanism is a fail-safe design, meaning that the RPM will be limited to a lower speed if the springs weaken or fail. This means that the turbine can self limit its top speed even in the heaviest winds or when the load is disconnected.

The wind loading on the blades also acts to orientate the turbine correctly in the wind, removing the need for a tail vane or yaw motor. This greatly improves the reliability of the turbine and reduces maintenance times and costs.

2.2 Generator

The generator converts the rotational energy of the rotor into electricity. It is built using rare-earth permanent magnets and has no touching parts or brushes meaning that it is maintenance free.

The permanent magnet generator is designed to produce power at low rotational speeds, eliminating the need for a gearbox. Again this greatly increases reliability with the added benefit of lower noise and more efficient operation.

The output from the generator is three-phase variable frequency and variable voltage (directly proportional to rotor speed).

The generator is robust can be physically disconnected from the load at any time without any problems - in this case the output voltage will rise and the turbine will speed up slightly until the pitch system controls the turbine at its maximum rpm.

WARNING: A PERMANENT MAGNET GENERATOR PRODUCES A VOLTAGE WHENEVER THE ROTOR IS TURNING - CAUTION MUST BE EXERCISED AT ALL TIMES TO AVOID ELECTRICAL SHOCK.

2.3 Nacelle

The nacelle is the main body of the turbine and contains the structural backbone of the wind turbine. It houses and protects the generator, manual pitch system, yaw bearing and brush gear from the elements. The mainframe is manufactured from steel and is protected with a hot dip galvanized finish. The removable glass fiber generator cover enables easy access to the generator and other components, whilst giving a clean and modern finish.

2.4 Control System

The turbine control system is made up of the following parts. Unlike other turbine manufacturers we manufacture our own control system and inverters, enabling these to be matched exactly to the performance of our turbines. This increases reliability, improves efficiency and reduces installation time.

Turbine Controller

The turbine controller is the first stage of the control system. This takes the electricity generated by the turbine and rectifies it ready for the control system inverters. The controller also contains overvoltage protection and can bring in braking resistors to help control the turbine in high winds.

Braking Resistors

The braking resistors are used to help slow the turbine down when the control system detects that the wind speed is very high or in case of grid failure. They are only used rarely when required by the control system and do not waste ‘useful’ power: the energy dumped is in addition to the published power curve.

The use of braking resistors ensures that the turbine is always under control and that the inverters are protected from harmful high voltages in the event of a grid failure.

Inverters

The inverters are custom made to suit the Osiris 10 wind turbine and are matched exactly to its power curve for optimum efficiency. Setup is quick and easy and there is no complicated programming required.

The inverters take the rectified power from the turbine and construct perfect, grid quality electricity which meets all requirements of the UK national grid. The inverters are easy to connect and can be configured for single phase or three phase installation.

As the inverters are specifically designed for wind turbines rather than PV they have the widest voltage tolerance of any inverter on the market. They are designed to cope with overvoltages of up to 600V with no adverse effects.

3 Health and Safety

The long term safety of the wind turbine depends on a number of issues that both system designer and installer must address. Potential hazards need to be identified and eliminated or minimised. This does not just include those which may be present during installation but also any that may develop over time.

Poor installation can compromise the long term safety of the system. Equally, unsafe site and working conditions can put installation engineers at risk. Correct design of the system as well as thorough planning of the installation phase will help to ensure the quality of the installation as well as the safety of the work team.

INSTALLERS NEED TO TAKE NOTE OF THEIR STATUTORY DUTIES UNDER HEALTH AND SAFETY LAW AND ARE RESPONSIBLE FOR ENSURING COMPLIANCE WITH THE LAW.

The Construction (Design and Management) Regulations may also apply if more than four people will be involved in the construction work at any one time. The project is notifiable to the Health & Safety Executive if it will exceed 30 days or involve more than 500 person-days of work. However, there are exceptions to this.

As part of standard Health & Safety practice, a Risk Assessment should be completed. This is a legal requirement under the Management of Health & Safety at Work Regulations 1999.

Special attention should be given to the following points:

- Due regard should be given to any public rights of way close to the installation site
- The specific local situation should be taken into account, e.g. the likely presence of children or animals
- Existing site services (e.g. overhead or underground electric cables) should be identified and exclusion zones defined
- Temporary signs, notices and barriers should be erected
- The local weather conditions should be considered. Osiris does not recommend the installation of turbines in wind speeds greater than 6 m/s.
- Structural and mechanical installation must be actively managed and supervised by a suitably experienced and competent person.
- Before each day's operations commence all workers involved in the works must be fully briefed on the day's events and method statements in a toolbox talk. This is to include the identification of danger areas and potential health and safety issues identified in the risk assessments.
- All personnel must wear appropriate personal protective equipment, including high visibility jackets, hard hat and safety boots
- During installation and maintenance works, an exclusion zone shall be established to prevent persons not engaged with erection of the turbine from gaining admittance
- Standard precautions for working with rotating machinery should be taken: long hair should be tied back; loose clothing avoided; rings, necklaces and other jewelry removed.

4 Turbine Siting

4.1 Planning Permission

The planning authority may impose restrictions on the sitting of a wind turbine. These restrictions are normally due to two reasons:

- Ø Expected noise output
- Ø Visual impact on the landscape

These restrictions will be particular strong in National Parks or areas of outstanding beauty. However it should be noted that this does not mean that planning will not be granted and there are lots of examples of Ginlong size wind turbines installed in these areas.

The customer should be made aware of any restrictions that might occur. In assembling information for the local planning authority, the latest planning guidance and recommendations should be taken into account.

In support of a planning application, installers should:

- Ø Advise customers to make contact with the local planning authority themselves
- Ø Urge customers to communicate with neighbours and the local community about the project at an early stage
- Ø Provide information to the authority on similar installations (location, equipment type, etc)
- Ø Provide appropriate drawings
- Ø Provide information on noise levels

Osiris can provide a Planning Pack on request which contains a lot of useful information for use during planning application.

4.2 Location

The ideal site for a wind turbine is on a smooth, rounded and exposed hill-top or rise; one clear of any cliff faces and many metres from obstructions such as trees and buildings. In practice this very rarely happens. Where it is not possible to achieve the ideal location the additional risks and Health & Safety considerations must be carefully weighed.

When locating a wind turbine there is normally a compromise between 5 main factors:

Wind direction: a turbine should be exposed to prevailing winds, i.e. the direction with the best overall combination of frequency and strength. In most UK locations, the prevailing winds come from the south west.

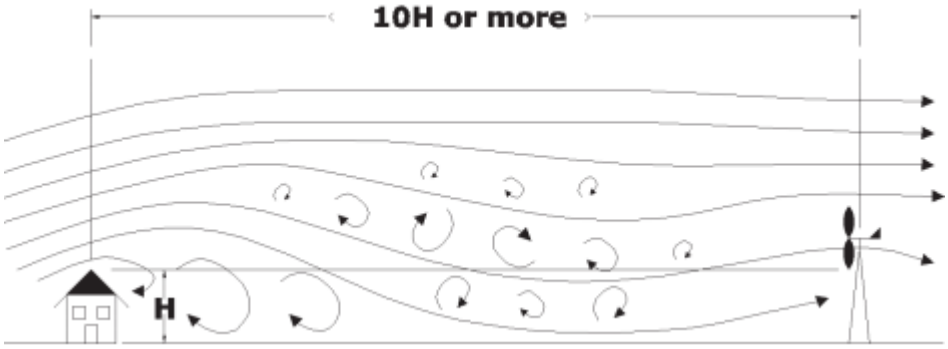
Obstacles: wind speed increases with height as the ground and objects close to it disrupt air flow. The 'roughness' of the ground is a measure of the way obstacles such as trees, buildings and the surface topography act to effectively slow down the wind. When sitting a wind turbine the installer should take account of possible future obstructions such as tree growth.

The wind turbine should ideally be placed well clear of any buildings, obstructions and places where the public may gather

Turbulence: the flow of the wind is disrupted when it passes over or around objects, so a turbine should be sited to minimise the influence of obstacles (ideally from all directions). Excessive turbulence may also cause fatigue and shorten a turbine's life.

Tower height: while greater height will increase energy output (higher wind speed and less turbulence, especially at sites of greater roughness), practical considerations such as cost and ease of lowering (for maintenance) also need to be taken into account.

Cable Length: losses from cables will result in a reduction of overall energy output. Cable runs should therefore be kept as short a possible for optimum performance. The cost of underground cabling may also prove excessive if long cable runs are planned.



4.3 Safety Zones

The Osiris 10 is designed with safety first are foremost. Despite this, serious mechanical failures could in theory lead to parts falling from the wind turbine. In preparing a site risk assessment the following safety zones should be taken into account

Zone	Zone Radius around turbine	Hazard	Guidance
1	Tower Height	Falling Part	Exclusion zone. In public areas this should be protected using fencing.
2	Tower Height + Blade Length	Tower Collapse Part thrown	Low occupancy zone. This area should generally be kept clear and occupied no more than 3 person hrs n per day
3	50m	Part thrown	Average occupancy zone, typical occupation of 200 person hours per day

4.4 Multiple Installations

Where multiple installations are intended at a single site extra care should be taken. This includes ensuring that no turbine is in the wind shadow of another turbine and also that there is adequate space to lower each turbine to the ground.

Osiris recommended a spacing of a minimum of 3.5 rotor diameters apart to prevent interference.

4.5 Noise

Modern wind turbines such as the Osiris 10 are designed specifically to minimise noise using a direct drive generator which operates without a gearbox and has a low rpm whilst maximising power production. This means that the only noise is that caused by the swish of the blades in the wind and this is often masked by the background noise in the area.

However despite this, customers should be made aware of the expected noise levels and given clear and honest advice about what the noise levels mean.

As a rough guide the minimum distance from properties should be at least 6 x rotor diameter.

4.6 Shadow Flicker

Shadow flicker is an effect caused when the sun passes behind the rotors of a spinning wind turbine and casts a shadow of the blades over neighbouring properties.

In the UK, only properties within 130 degrees either side of north, relative to the turbines, can be affected, as turbines do not cast long shadows on their southern side. Also, the further the away from the wind turbine, the less pronounced the effect becomes. Flicker effects have been proven to only occur within ten rotor diameters of a turbine.

5 Mechanical Installation

5.1 Foundations

See separate foundation installation guide for details. The foundations should be installed a minimum of two weeks before turbine installation.

5.2 Tower

Weights

	12 m Tower	15m Tower
Base Section	280kg	366kg
Lower Section	1135kg	1150kg
Middle Section	-	942kg
Top Section	650kg	583kg

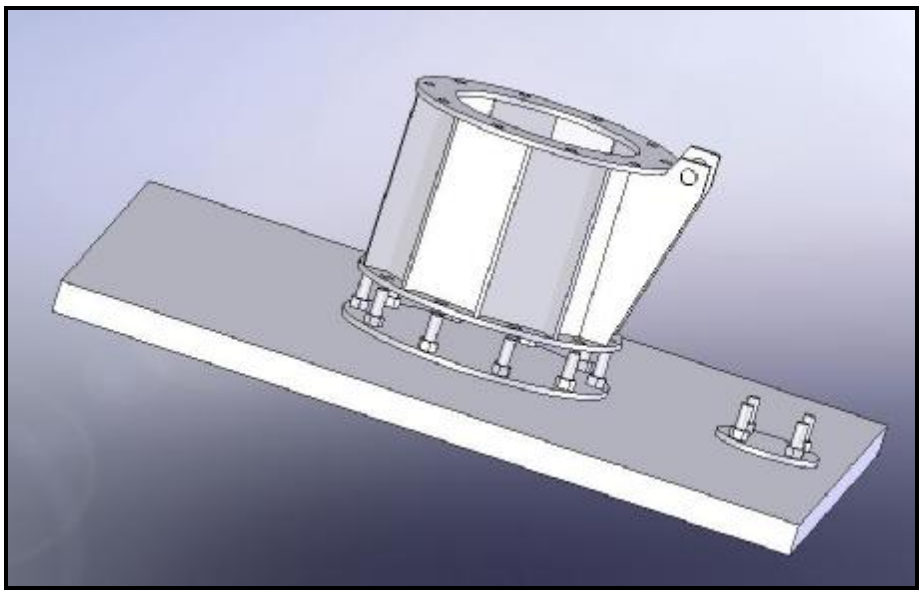
Installation procedure

The tower installation must be carried out with certified lifting slings. A nominated signal man must be used to direct the lift and ensure the lift is carried out in a controlled and safe manner. The lift area should be cordoned off and no unauthorized personnel should be allowed to enter.

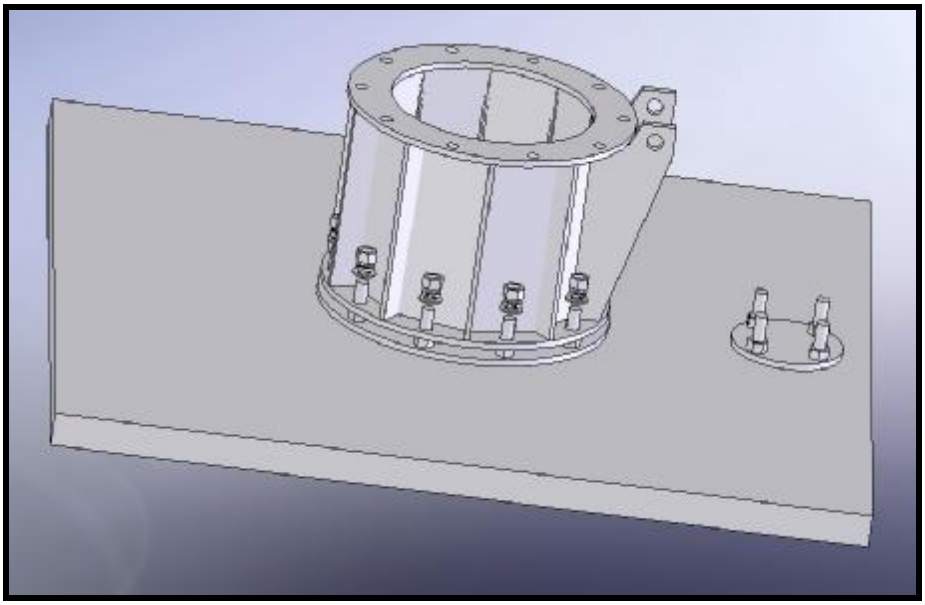
The importance of leveling the tower can not be underestimated. The Osiris 10 is a downwind passive yaw turbine and as such can experience yaw problems if the tower is not adequately leveled. Levels should be checked throughout the tower installation to ensure the tower is not pulled out of level.

The tower installation should only take place in winds less than 6m/s

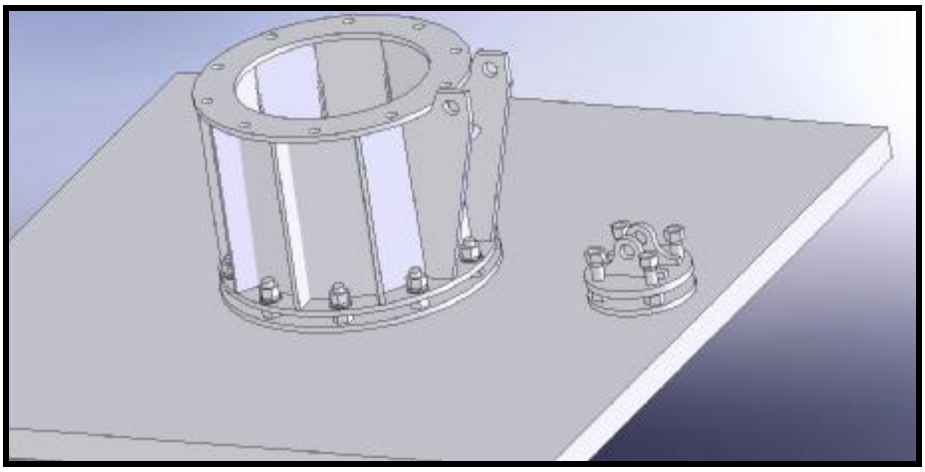
- Lift parts off vehicle using slings. Ensure that the lift is correctly balanced and that the vehicles lift capacity is adequate for the work.
- Take tower sections to foundation and layout in the correct positions for assembly.



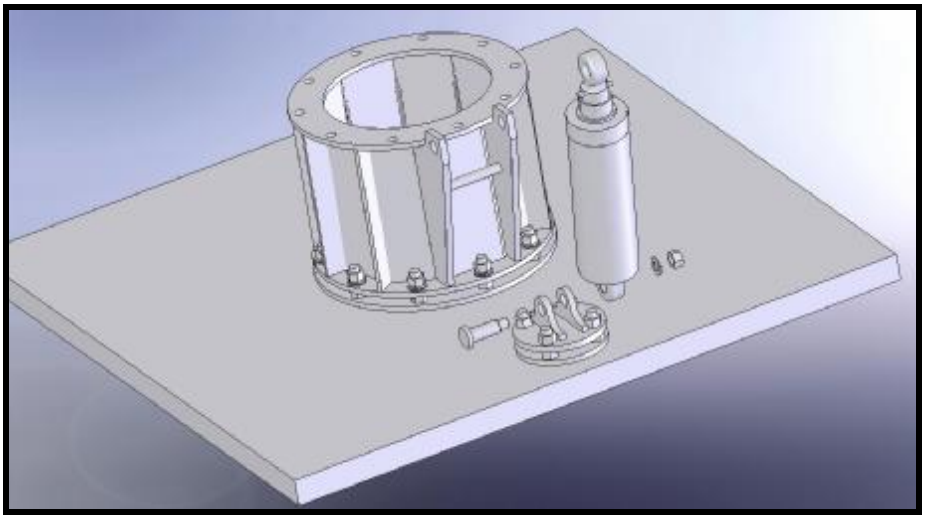
- Raise up 3 of the M36 foundation nuts (at 120 degrees from each other) by three turns so that the three nuts are around 2mm higher than the others. Using the spirit level adjust the nut heights until the three nuts are level.
- Lift up the base section and lower over the foundation bolts resting the piece onto the three raised nuts. Make sure that the hinge section is correctly aligned with the hydraulic cylinder base plate.
- Once the base section is lowered double check the level of the top flange. If the level is more than 0.3 degrees out of level then readjust the base bolt height to ensure that top flange is level.
- Once the top flange is level install the washers, lock washers and top nuts onto the three leveling foundation bolts. The nuts should be pre tightened gradually together whilst watching the spirit level, always ensuring that the top flange remains level.



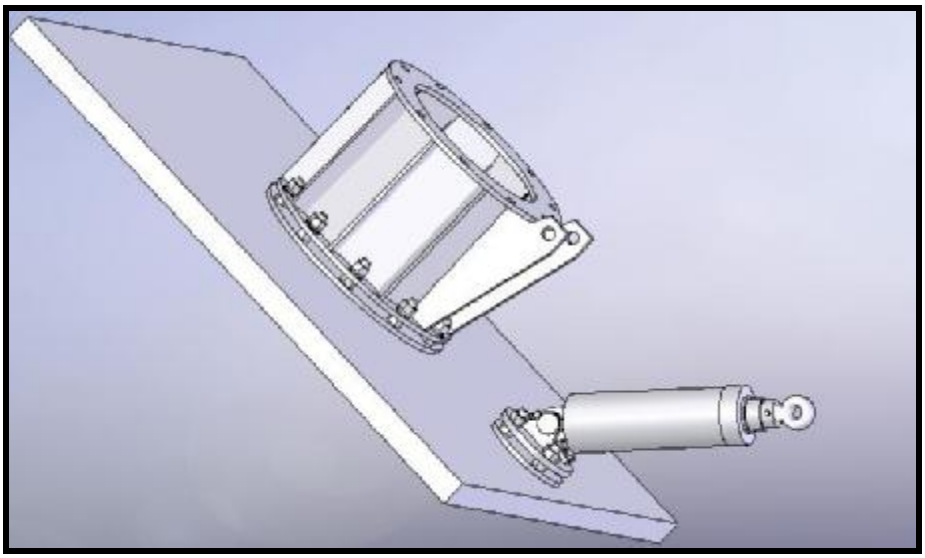
- Once the three leveling bolts are tightened the remaining nuts can be brought up under the flange. Installer washers, lock washer and top nuts onto the foundation bolts. Whilst still watching the spirit level bring all M36 bolts up to 1700Nm using hydraulic torque wrench. It is best to do this by torquing bolts in a cross pattern to ensure the flange remains level.
- Next install the hydraulic cylinder base pad onto the 4 cylinder foundation bolts. Install the fixing nuts and torque up to 1100Nm.



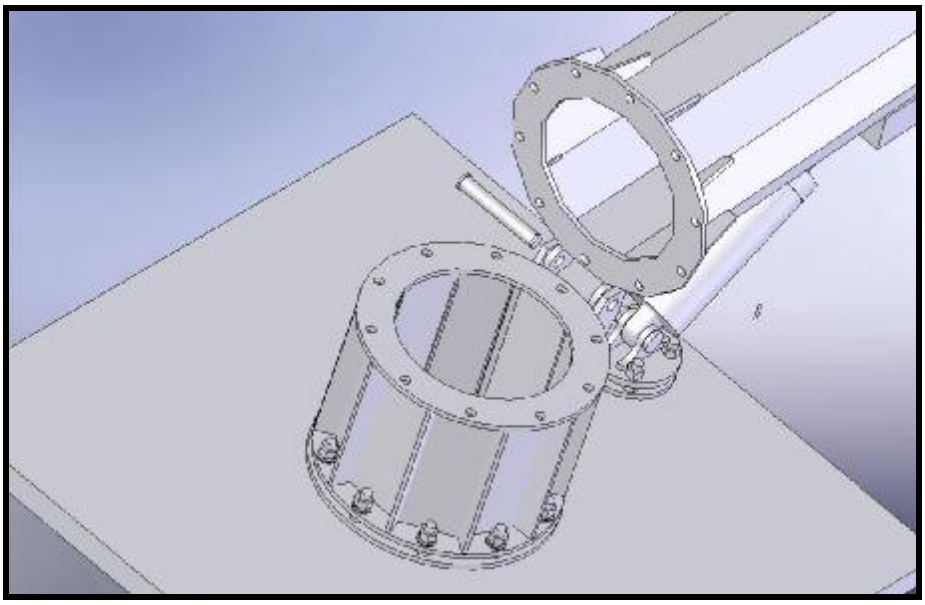
- Lift up the hydraulic cylinder using a sling through the pin hole and move into location above the cylinder base plate. Insert the fixing pin through the cylinder and base plate and tighten up the nut. When tight it should still be possible to move the cylinder around the fixing pin.

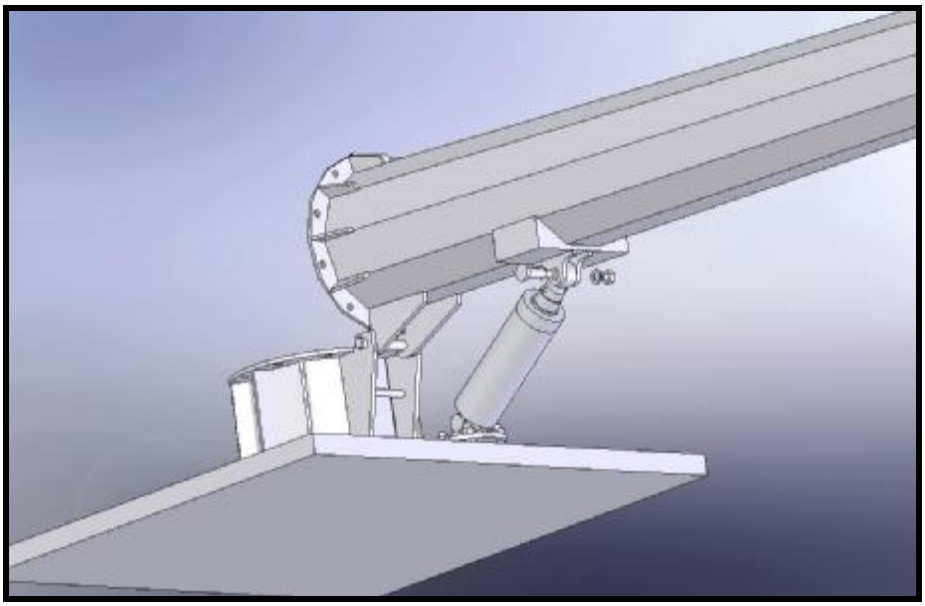


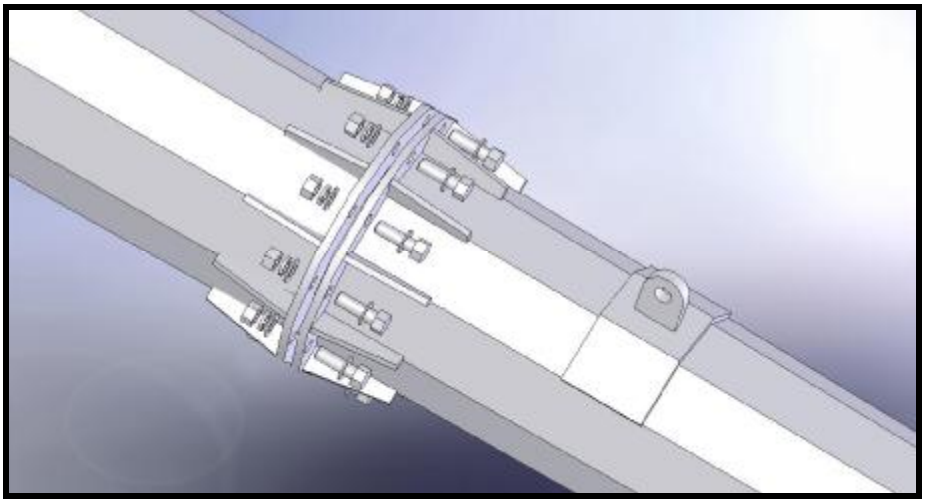
- Using a steel trestle it should now be possible to support the cylinder at a 35 degree angle ready for the installation of the lower tower section.
- Connect up the hydraulic power pack to the lift cylinder using the supplied hoses. Fixing should be tightened to around 80Nm. The power back should be connected to the mains supply and be filled with hydraulic oil. It is recommended that the operation of the power pack and cylinder is confirmed before proceeding with the installation.



- Lift the lower tower section using the lifting vehicle. The lower section should be installed onto the hinge pin and the hydraulic cylinder attached to the tower. To help with this the tower should be supported on trestles. The cylinder can be raised or lowered using the power pack to aid this fixing.





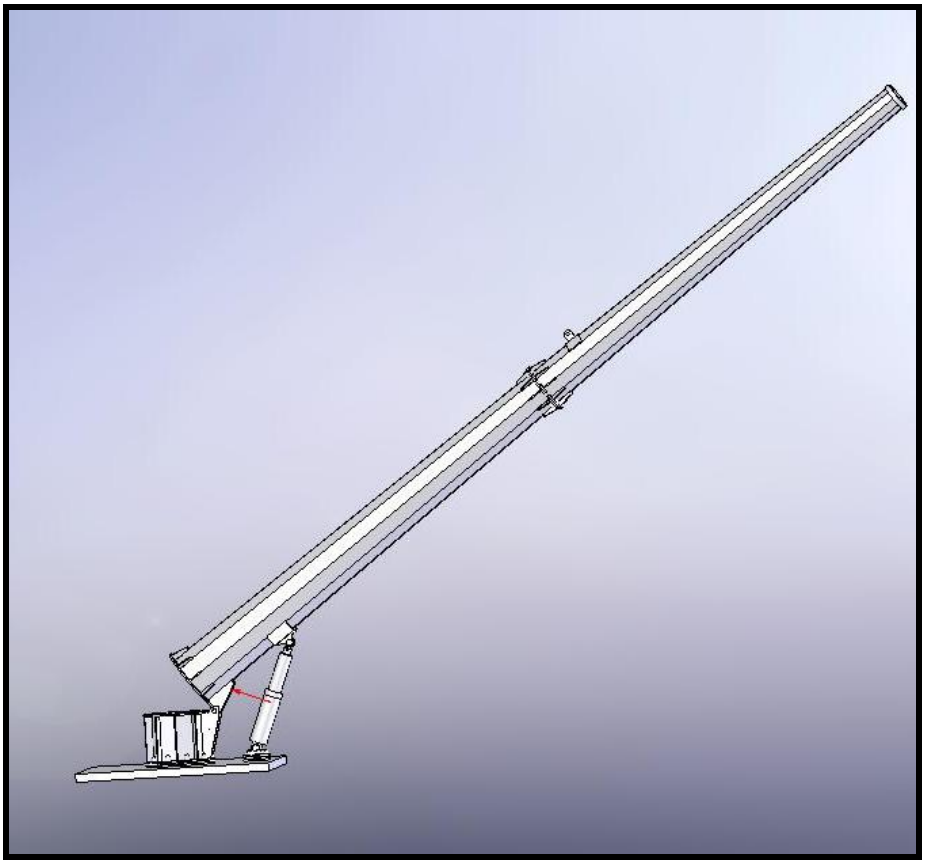


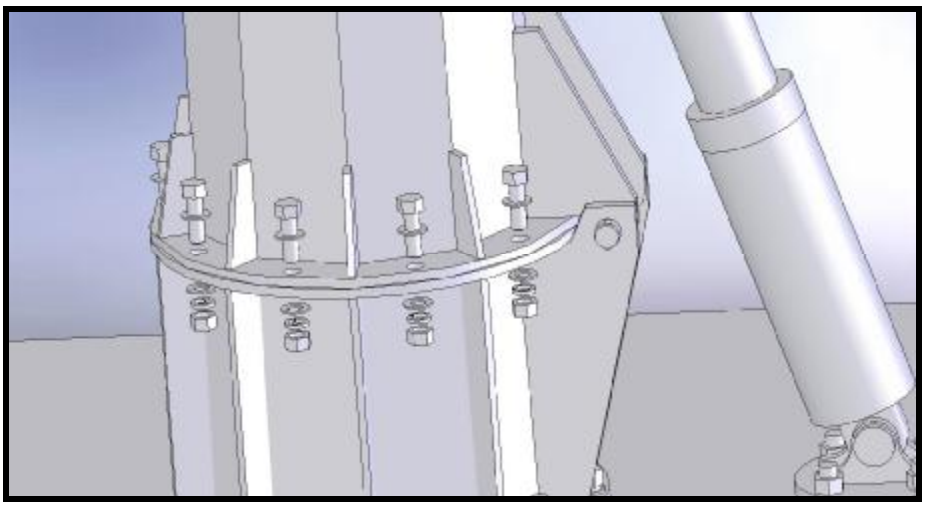
- Lift top section of tower into position and align flanges with the tower. Ensure the cable loops inside the tower are aligned.
- Bolts flanges together using M30 bolt, washers, and spring washers. Cross fasten the nuts and bring up to 1300Nm
- The tower generator power cable and earthing cable should now be threaded down the tower, ensuring it passes through each cable loop. The use of thin cable rods is recommended to make this process easier. Please note that the tower cable is not provided by Osiris
- The tower is now ready for head installation. Ensure the tower is well supported and is not relying on the lift cylinder to support its weight. For head installation instructions see the section below.

Tower Raising

- Once the head has been installed the tower can be raised. Start the hydraulic power pack and manually rotate the pressure valve to raise the tower. When using the hydraulic power pack it is important to keep the flow rate low, ensuring the flow rate is slow and uniform. If the flow rate is too high the tank may vibrate and jitter which could cause damage to components.

- Once the tower is raised the final set of bolts can be fastened. Fit with M30 bolts, washers and spring washers. tighten to 1400Nm. The level should be checked using a digital spirit level against the vertical sides of the tower. Each flat face should be equally angled.





- After tower installation, remove the cylinder and store safely.

Earthing

The exact earthing of the turbine is at the discretion of the system designer and depends on the particular site and ground conditions. If in doubt about tower earthing please seek professional assistance.

In general the following recommendations should be followed

- The turbine tower is to be connected to a dedicated earth electrode. An electrode resistance to earth not exceeding 10 Ohms should be achieved, though may not be justifiable in some cases.
- The earth electrode shall be placed as close as is practical to the tower base and it must be installed in such a way as to permit periodic inspection. Periodic inspection is important as a failure of this earth termination may have a serious impact on the system, not least in the transmission of lightning surges
- The connection between the tower and the tower earth should be made with copper cable (minimum CSA of 16mm2), taking a direct route and avoiding sharp bends
- Separation between the turbine earth and building earth is to be maintained. This is to ensure that any direct strikes on the turbine (which may be in a particularly exposed location) are not coupled directly back to the building
- The steel wire armor of the turbine output cable should not be coupled in any way to the tower earth and so bring the turbine earth inside the building. This could occur if a metal junction box is used to join cables within the steel turbine tower; the metal box would be coupled to the armoured sheath by the SWA gland and also coupled to the tower by direct contact. In such a situation, a non-conductive enclosure must be used.
- An earth wire should be taken up the turbine tower and connected to the earth wire from the nacelle. This earth wire passes through the earthing brush gear and ensures the nacelle body is connected to the tower earth

Lightning protection

BS 6651 Code of practice for protection of structures against lightning describes how to assess the likelihood of damage. This may be caused either by a direct strike or through surges induced in cables from a nearby strike. Tower earthing (see above) provides one element of protection.

a) Dedicated Lightning Protection Systems

If there is a risk of a direct strike, specialists should be consulted about installing a separate LPS in accordance with BS 6651.

b) Surge protection

- Cabling systems can be designed to provide a degree of surge immunity. The following measures will act to shield the cables from inductive surges and attenuate surge transmission (by increasing inductance):
- Turbine output cables should be as short as possible, bundled together and not looped
- Long turbine output cables (for example, those over 50m) should have an earth shield, which can be created by using earthed, armoured cable or earthed metal conduit/trunking
- Surge suppression devices will give additional protection:

- Where these are fitted to the turbine output cable, they should be attached at the tower base. In the case of long cable runs, they should be fitted at both ends
- Where surge suppression devices are fitted to protect specific equipment, they should be fitted as close as is practical to the device
- Surge suppression devices must be electrically safe and pose no electrical fire hazard

5.3 Turbine Head

To enable easy fitting of the nacelle it is usual to lift the tower to a suitable working height, usually with the hub at shoulder height. This can be done using the hydraulic power pack and cylinder; however once at height it is important that the tower is supported using trestles near the head end.

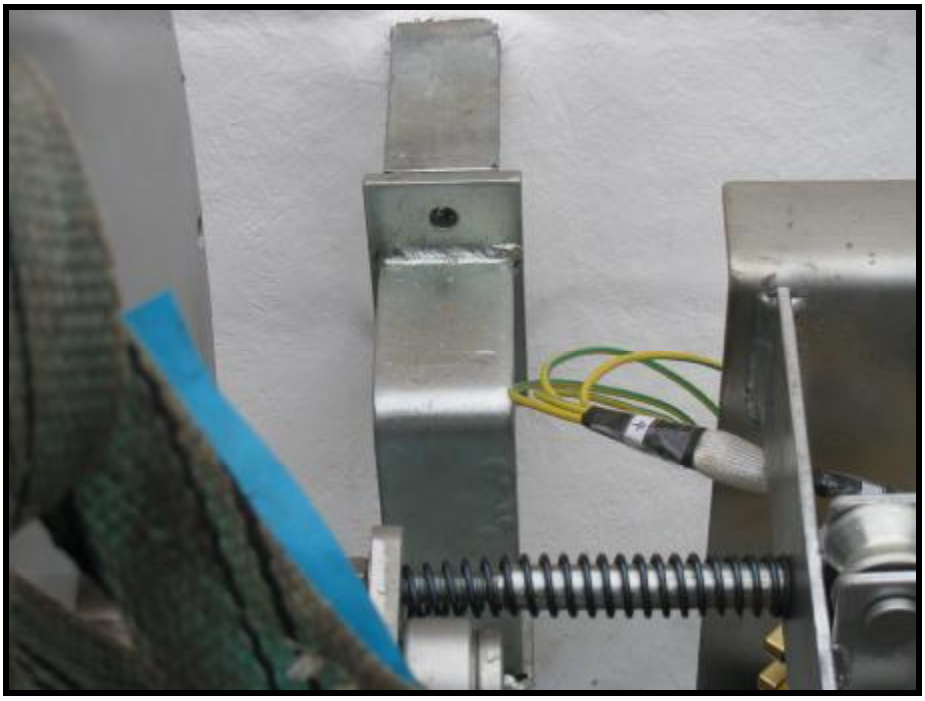
NEVER WORK UNDER THE TURBINE WHILST RELYING ON THE LIFT CYLINDER TO HOLD THE WEIGHT. THE TOWER SHOULD ALWAYS BE SUPPORTED BY OTHER MEANS IN CASE OF LIFT CYLINDER FAILURE.

Nacelle Assembly

- Unpack the nacelle and inspect for any signs of damage. The enclosed parts should also be checked against the packing list. If any parts are damaged or missing then please contact Osiris immediately and log as nonconforming goods. Damaged areas should be photographed as evidence of damage occurring during shipping.

- Open up the top cover of the nacelle exposing the brush gear and manual pitch mechanism. Again check for any internal damage and contact Osiris immediately if there are any concerns.

Ø Unbolt the lower nacelle cover from the main frame. There are four brackets holding the lower cover on as shown below.

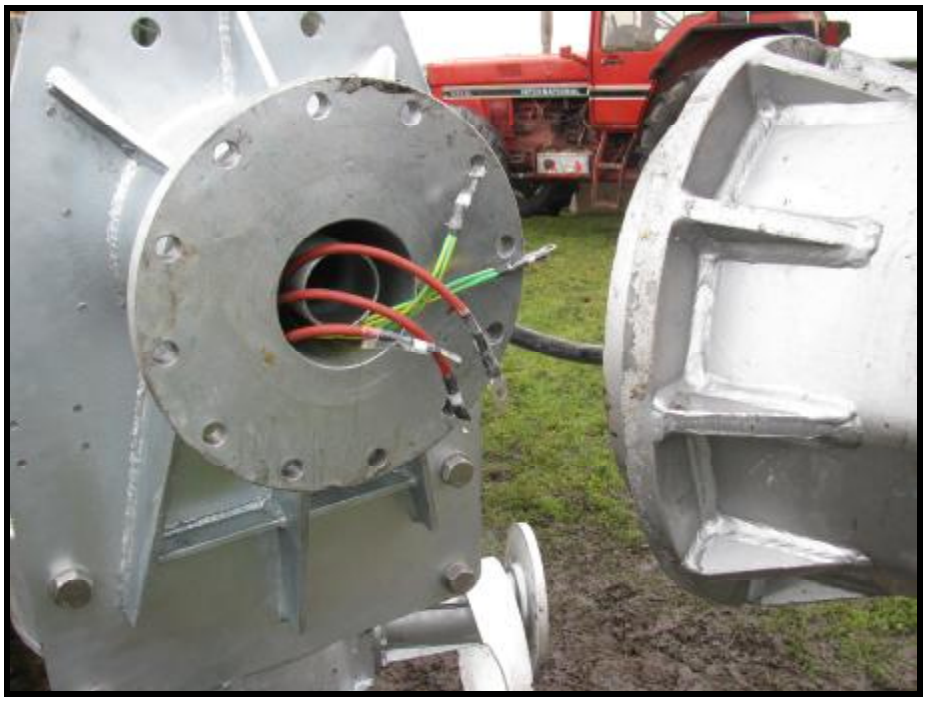


Ø Once the brackets are undone the top flange needs to be unbolted from the wooden transportation frame. This can be quite tricky and we recommend the use of a swivel ended socket spanner suitable for an M16 bolt (sometimes referred to as a scaffolding spanner)

- Once the lower cover is removed the mainframe and generator can be lifted out of the bottom cover and placed in a safe location. There are installed eyebolts on the generator and subframe and these should be used along with rated lifting slings and shackles to get a balanced lift/
- Next lift the lower cover and slide over the tower top.

- Next the main frame should be lifted using one sling and shackle on the mainframe lifting eye and the 1T chain block in the generator lifting eye. Once the mainframe is lifted on the ground the chainblock should slowly be lowered to rotate the main frame into a vertical orientation (with nose towards the ground)

- Move the nacelle next to the top tower flange. Align the flanges so that they are approximately 300mm apart. This is to allow electrical cables to be connected and pitch wire to be threaded down the tower.



- Pull the three power cables and two earth cables from the nacelle flange. These should be connected to the tower cables using terminal bloc connectors. Also ensure that the tower earth cable is attached to the nacelle earthing cable (Please note this should be from the tower earth and should be isolated from the building earth)

- Pull the steel rope up from its location in the nacelle and pass over the pulley wheel and through the base of the mainframe.

- Thread a cable rod down the tower and attach this to the end of the steel wire. Pull the wire through the length of the tower to the base.

- The manual pitch handle should then be assembled in the base of the tower. Thread the steel wire through this so that the system will grip the wire and allow it to run over the free moving bolts when turned.

- Once all cables are connected the two flanges should be brought together and fastened using M16x60 hexagon bolt, washers, and lock washers. These should be fastened to 320Nm.
- Once the flanges are fastened to the correct torque, pull up the bottom nacelle cover and fastenonto the generator base plate using M8 x 25 bolts and nuts.

- Once the lower cover is installed the turbine is now ready for blade installation

Fitting Blades

- Unpack the blades from their packing crate. Be careful when opening to ensure the blades do not fall out. Treat the blades with exceptional care - especially the leading and trailing edges of the airfoil. The blades are supplied as a balanced and matched set of three and must be installed together on a single turbine.

- To enable easy fitting of the blades it is usual to lift the tower to a suitable working height, usually with the hub at shoulder height. This can be done using the hydraulic power pack and cylinder; however once at height it is important that the tower is supported using trestles near the head end.

Never work under the turbine whilst relying on the lift cylinder to hold the weight. The tower should always be supported by other means in case of lift cylinder failure.

- Take care to fit the blades in the correct orientation. Note that the blades turn in a clockwise direction when viewed from the front of the rotor (ie anticlockwise when looking down on the blades). It is possible to fit the blades in the opposite direction and this could lead to dangerous situations occurring therefore installers should check carefully before bringing the bolts to full torque.

- Before installing the blades ensure that the blade hub covers are installed on the turbine

- The blades may be bolted onto any position of the three blade hubs and it is essential to support the blades weight whilst they are being installed. When connecting the blades to the blade hubs start inserting the M12*50 bolts from the front side of the blade hub and secure with the provided lock nuts and washer. The bolts should be torqued to 70Nm in two steps: First torque all bolts in an even progression upto 45Nm, then to 70Nm.

- Ø After all three blades have been fitted and bolts torqued wait 30mins before re-checking torque.
- Ø Next the nose cone should be fitted using M8 and M10 bolts. The blade hub covers should also be fastened to this. Once the nose cone is in place turn the rotor to check for any interference between nose cover and main turbine head body.

- Ø The manual pitch should now be tested and checks should be made for interference between blade bolts and the hub covers. If interference does occur the nose cone should be adjusted
- Ø Finally the top cover can be fitted and the turbine is now ready for erection.

6. Electrical System Installation

All work is to be undertaken by experienced, competent and authorised personnel who are fully familiar with standard working practices within the electrical industry and who are acquainted with the maximum voltages present on the system being installed

Live working practices are to be adopted during the initial connection of the turbine to the main output cable (see Regulations 4(4), 14 and 15 of the Electricity at Work Regulations 1989 and also BS EN 6093 and BS EN 60900)

Subsequently, the turbine isolator must be secured open for all other works on the electrical system. Relying only on the pitch or shorting brake to prevent against shock is not acceptable

6.1 General Description

The main components of the electrical system are:

Turbine Junction Box (not provided)

A turbine junction box is required where turbine output cables are to be joined.

The box must be labeled "Wind Turbine Junction Box - Danger, terminals may come live at any time". All labels must be clear, easily visible and should be constructed and fixed so as to remain legible and in place throughout the design life of the system.

Turbine Generator Cable (not provided)

The turbine generator output cable must be able to withstand the environmental conditions, as well as the voltage and current, at which it has to operate. It must be rated to suit the environmental conditions along its entire route i.e. it should be UV-stable, waterproof, armored, etc. This shall be calculated using standard correction factors for installation method, temperature, grouping and frequency, in accordance with BS 7671. Sizing the cable in this way ensures that the maximum potential fault current can be safely accommodated. Correctly sized cables will avoid the fire and safety risks associated with overloading.

In conventional systems, cables are protected by a fuse; this rapidly clears a fault before it becomes a fire or safety risk. With a wind turbine, however, the steady state fault current may be only a little more - or sometimes less - than the maximum operating current. In such cases, sizing a fuse to achieve disconnection under fault conditions is not possible. Instead, cable systems with suitable rating and protection are to be selected so as to minimise the risk of faults; Steel Wire Armoured (SWA) cables may be used, or the cables enclosed in protective conduit/trunking.

The turbine output cable should, in general, be sized so that the voltage drop along it (at the rated output power of the turbine) is less than 4%. In some circumstances, a voltage drop greater than 4% may be justified on economic grounds.

See the Osiris cable calculator sheet for more guidance

Osiris Turbine controller

This provides the interface between the turbine and the grid connect inverter. The Turbine Controller converts the three phase AC output of the wind turbine to DC for input to the inverter.

It also has the ability to help control the turbine speed in high winds by bringing in the braking resistors to slow the turbine down. It does this by detecting a rise in the DC voltage above a preset level. If this is detected the control system will gradually divert the surplus current to the brake resistors. The current

diversion is performed using advanced high frequency, pulse width modulation (PWM) switching to ensure smooth control of the turbines speed.

The brake resistors are simply resistive elements that are used to dissipate the power generated by the turbine. They are only used in extreme conditions or in the event of turbine technical problems, however when used they may get hot. The choice of location should be carefully considered and they should be placed out of reach and at least 500mm from any other risks of fire. An ideal location would be high up on an outside wall.

The three wires of Generator connected to IN1,IN2,IN3; The resistor box's two white wires shall be connected to B1,B2, and the yellow/green one connected to G; DC+,DC- are the output dc ends, connected to inverter's input terminals; the right terminal G connected to building earth.

There are two dip switches located in the controller. By default these should be set 1on and 2 off. It is important to check these settings before starting up the turbine.

Dial switch	Dump load switch-on voltage / V	Dump load switch-off voltage / V
1,2 off	330	250
Default: 1on 2 off or 1off 2 on	410	330
1,2 on	490	410

Turbine Isolator (not provided)

A turbine isolator manually isolates the electrical output of the turbine. This will be necessary during system installation and also for maintenance and repair work. A shorting brake on the turbine is not sufficient to guarantee supply isolation.

The turbine isolator must be a multi-pole device in order to electrically isolate all the wires coming from the turbine. The isolator must also be rated for operation at the maximum voltage and current of the turbine.

Anyone opening the isolator enclosure must be aware that turbine output cables can become energised at any time - indeed they often represent an additional energy source within a building.

The isolator enclosure should be clearly labeled "Danger, terminals may come live at any time". The enclosure should bear the label "Wind Turbine Isolator" with the ON and OFF positions clearly marked. All labels must be clear, easily visible and should be constructed and fixed so as to remain legible and in place throughout the design life of the system.

Osiris Inverters

The Osiris Inverters carry a current Engineering Recommendation G83 Type Test certificate and comply with all other parts of G83/1.

The inverters must be programmed so that the built in automatic protection system operates at:

- Operating voltage greater than 264V phase to neutral
- Operating voltage less than 207V phase to neutral
- Operating frequency greater than 50.5Hz
- Operating frequency less than 47Hz
- Loss of mains / islanding prevention

The inverters are specifically designed to match the output of the Osiris 10 wind turbine and should come preprogrammed with the Osiris 10 power curve.

Currently the system consists of 6 x 2kW inverters in parallel. For 3 phase systems a 3 phase converter will be provided for the inverters to be connected to.

Lockable AC isolator – Allowing grid to be securely isolated from the inverters (not provided)

Two AC switch isolators, in accordance with BS EN 60947-3 Specification for low-voltage switchgear and control gear, switches, isolators, switch-disconnectors and fuse-combination units, must be provided between the inverter and the point of interconnection to the supply. One is to be installed adjacent to the inverter and the other next to the point of interconnection. If they are to be in the same room, only the latter is required.

They must:

- Switch all live and neutral cables
- Clearly show ON and OFF positions and be labeled as "wind system - point of emergency isolation"

The isolator adjacent to the point of interconnection must also be lockable - in the OFF position only - and it must be easily accessible.

G59 Panel if required – (not supplied)

The output from the Osiris Inverters is synchronized with the mains electricity supply. Before connecting to the grid, installers must get written approval from the local Distribution Network Operator (DNO).

Guidance on connecting a small scale embedded generator (SSEG) can be found in Engineering Recommendations G83/1 or G59. G83 applies to turbines who output less than 16A per phase and G59 applies to larger turbines. Due to the size of the Osiris 10 wind turbine, if connected three phase DNO's may accept the turbine under G83 however if connected single phase it is likely they will insist on G59.

If the DNO judges that the turbine should be connected under G59 then a separate protection control system will be required. This is known as a G59 panel and should contain a dedicated protection relay and contactor.

Design, testing and commissioning of these systems needs to be done in full consultation with the DNO and it is likely the DNO will require to witness test the system being setup and tested on site before grid connection will be allowed

ROC Meter (not supplied)

As a minimum, metering should be installed to display instantaneous power output and to record energy delivered by the wind turbine system. The meter should be fitted as the last stage in the control system before the customer's distribution board. The meter should be of a type approved by OfGem.

Consideration should be given to placing the meter where the consumer can read it. Not only will it add to customer satisfaction if the output can be viewed, but it should lead to more effective fault detection. A spinning turbine is not necessarily a working turbine and only metering can demonstrate correct operation.

For grid-connected systems to receive payment on exported electricity / ROCs, the installation of an additional export meter may be required, and this should be discussed with the nominated electricity supplier.

AC Cabling (not supplied)

The inverter(s) must be connected, via a dedicated circuit, to a spare MCB in the main distribution unit, or to a MCB in an additional dedicated distribution board.

AC cables are to be specified and installed in accordance with BS 7671.

When generating, the voltage at the inverter terminals is slightly higher than that at the distribution board. This voltage drop must be kept to a minimum so that the protection systems operate correctly. To do this, the AC cable between the two should be oversized in order to keep the voltage drop small - a 1% drop is acceptable.

AC fault current protection (not supplied)

The short circuit current from the inverter is approximately equal to its full load current. Over-current protection devices cannot therefore distinguish between full load and fault conditions.

Therefore short circuit protection is not feasible - or required - at the inverter output.

If installed 3 phase a 20Amp 3 Phase MCB must be provided at the distribution board to protect the mains cable.

If installed single phase a single phase 50 amp MCB is required.

This electrical protection is to be specified and installed in accordance with the requirements of BS 7671.

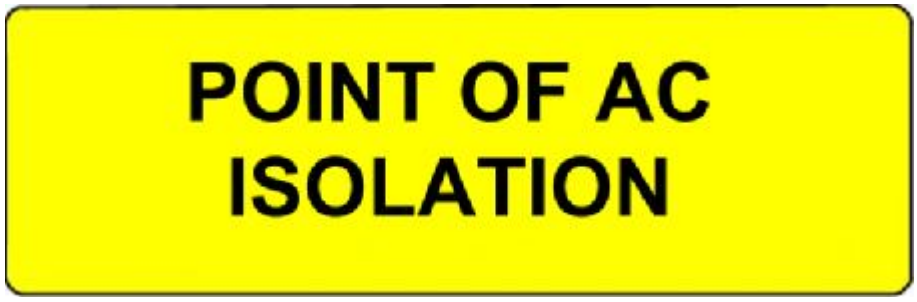
6.2 Signs and Labels

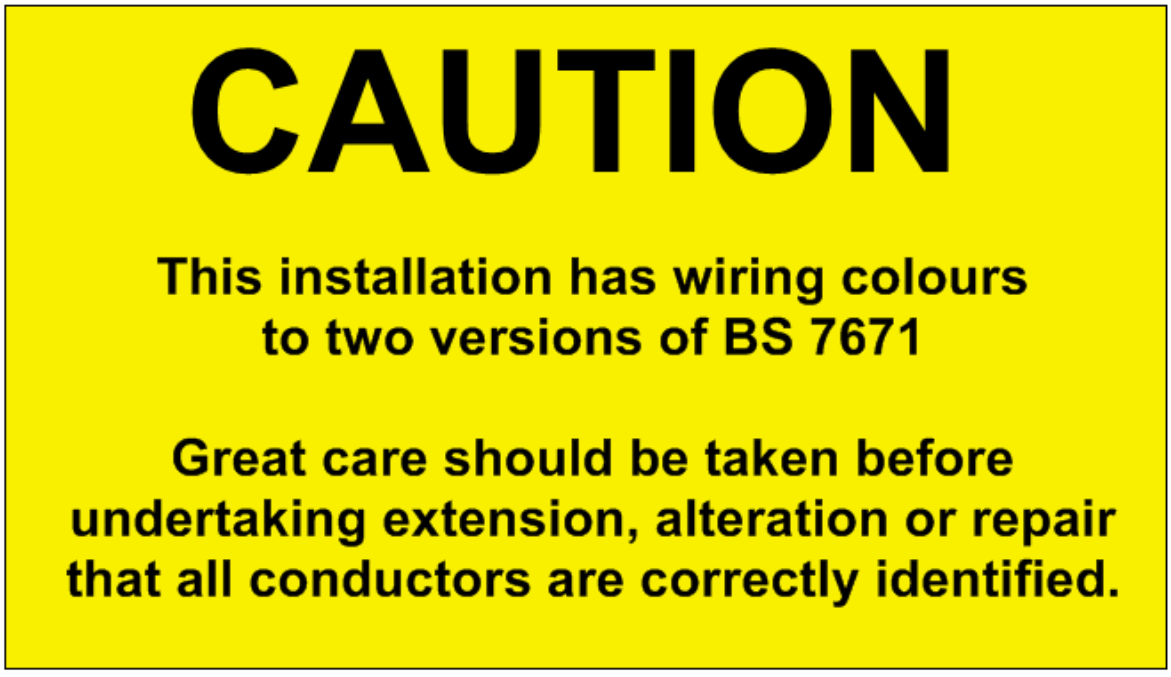
Labeling must be provided at the service termination, meter position and all isolation points in order to indicate the presence of on-site generation and to show the position of the main AC switch isolator.

At the interconnection point, the following is also to be displayed:

- Circuit diagram
- Summary of protection settings that have been incorporated in the equipment
- A contact telephone number for the supplier/installer/maintainer of the equipment.
- A detailed emergency shutdown procedure

All labels must be clear, easily visible and should be constructed and fixed so as to remain legible and in place throughout the design life of the system. Example labels are shown below:




CAUTION
This installation has wiring colours
to two versions of BS 7671
Great care should be taken before
undertaking extension, alteration or repair
that all conductors are correctly identified.

7. Commissioning

7.1 Tests

With the tower lowered, the turbine stationary and the controller isolated first check for generator circuit continuity and insulation to ground with the generator leads disconnected at the turbine connection box.

Resistance between all three lines should be equal. Insulation resistance to ground using a 500V insulation tester should be more than 2 Meg.

After the tower has been raised check the operation of the manual pitch mechanism.

If the wind speed is less than approximately 6m/s an open circuit test can be performed before connecting the turbine to the control system. Release the shorting brake and release the pitch to full setting. The turbine should begin spinning and the rotor should turn freely without significant vibration. If vibration appears excessive further investigation will be required before installation can be complete.

Whilst the turbine is running off-load check that the voltages between all lines of the output cable are equal using a digital multimeter. (Due to the varying frequency we recommend that a true RMS meter is used). The voltages between phases should be approximately equal (they will vary slightly due to gusting of the wind between readings)

A full electrical test of the system to bs7671 should be performed before proceeding with turbine startup

7.2 Start-up

At the start of commissioning ensure that:

- Ø The turbine shorting switch is on
- Ø The pitch brake is on
- Ø The turbine is isolated from the grid connect inverters
- Ø The grid connect inverter is isolated from the grid

To startup the turbine:

- Ø Turn on the Turbine MCB installed in the customer distribution board
- Ø Turn on the isolator labeled ‘Point of AC Isolation’
- Ø At this stage if the main is within the set parameters the G59 relay should energise (if included)
- Ø Turn on the isolator labeled ‘Point of Turbine Isolation’. We recommended that this isolator is only switched when the wind turbine is stationary to prolong the life of the unit.
- Ø Switch off the turbine shorting switch
- Ø Release the pitch brake

- The turbine will start to rotate if wind conditions are more than about 4m/s. At first release the turbine may sometimes take a small time to begin turning due to grease in the bearings.
- The inverter waits until input DC voltage is above a certain level before starting its self test and safety procedures. At this point the inverters start monitoring grid AC voltage, frequency and impedance. After a few seconds the GREEN LED starts to flash. If all is OK then it waits 180 seconds and then connects to the grid.

7.3 Certification Requirements

Inspection and testing of the completed system must be carried out to the requirements of BS 7671.

Accurate performance testing of a turbine is only possible where an anemometer reading at the hub height is available. For most small systems, such data will not be available. Readings from the system display meter will often be the only means to determine how well the system is working.

DNO Approval

If the turbine is being installed under G83 a notification certificate must be passed to the DNO.

If the turbine is being installed under G59 it is likely that witness testing with the DNO on site will be required.

7.4 Documentation Requirements

The following must be provided to the customer:

- Turbine foundation specifications - including, where appropriate, an assessment of local ground conditions as well as the installation requirements, specification of materials, etc
- Drawings, specifications and instructions for assembly, installation and erection
- This installation, maintenance and operation manual
- Original BS7671 Certificate
- G59 test certificate if applicable
- Commissioning certificate
- The customer should also be made aware that they should inform their insurance company of the wind turbine installation

8 Turbine Operation

If very high winds are expected such as wind speed greater than 25m /s it is recommended to manually change the pitch and apply the short circuit isolator.

If extremely high winds are expected (eg 42m/s) we recommended that the turbine is put on brake and the tower lowered.

During strong winds (wind speed of more than 9m / s) there may be some slight rocking of the tower and turbine head. This is normal and is expected behavior.

8.1 Starting Up

Remove the short circuit brake

Hold onto the manual pitch lever to prevent sudden movement as the locking bolt is removed. Remove the locking bolt and then slowly let the handle turn to remove pitch.

When the handle is stationary, remove the rope from the wheel to allow the pitch to be fully returned to normal.

In very high winds or when there is a turbine fault it may be necessary to apply the pitch brake. In these situations care should be taken as the turning force required will be greater.

8.2 Running

Once running the turbine requires no user intervention. The following gives an overview of the expected wind turbine behavior.

Behavior in no / low wind:

- Ø Inverter goes into wait mode after disconnecting from grid network.
- Ø If wind increases then the inverter will start up.

Behavior in Medium Wind up to 12m/s

- Ø Inverters automatically adjust power output depending on windspeed

Behavior in High Winds above 12m/s

- Ø Pitch mechanism will adjust blade pitch to maintain the 10kW output
- Ø If the pitch mechanism can not control the 10kW limit the control system will gradually bring in brake resistors to control the speed further

8.3 Stopping the Turbine

IMPORTANT: There is risk of burning out the generator by shorting the turbine in strong winds. We recommend that the manual pitch mechanism is first used to slow the turbine down before the shorting switch closed.

To bring in the manual pitch simply slowly turn the pitching handle. This will tighten the steel pitch wire and the force on the handle will increase. As the handle is turns the force will increase and the blades should begin to slow down.

Inside the tower is a M12 x 130 locking bolt. This should be extended into the fixing hole located on the manual pitch mechanism to lock the wheel in place.

Once the turbine has slowed down the short-circuit brake can be applied. The short circuit brake should only be applied once rotation reaches around 15rpm.

9. Maintenance and Inspections

CAUTION - PRIOR TO PERFROMING MAINTENANCE, FOLLOW PROCEDURE FOR THE PROPER SHUTDOWN OF THE WIND TURBINE

9.1 Service Schedule

To ensure your warranty remains valid the Osiris 10 should be maintained according to the requirements below. Maintenance must be carried out by suitably trained individuals.

This is especially important for turbines located in public places. Osiris installers should ensure a service contract is in place before installation of a turbine in a public area.

Service's should be performed to the following schedule:

We recommended that an initial inspection is performed soon after the first high winds experienced by the turbine (average wind speeds greater than 9m/s) or at 3 months, whichever is sooner.

Inspection and maintenance	Inspection Cycle			
	The first 3 months	Annual	Every two years	Every five years,
Tower Bolts	√	√	√	√
Blades	√	√	√	√
Rotor Fastener	√	√	√	√
Welding Inspection	√	√	√	√
Head Fasteners	√	√	√	√
Rotor Bearing Lubrication				√
Yaw Bearing Lubrication			√	√
Replacement of pitch springs			√	√

9.2 Annual Inspection

The Osiris 10 wind turbine requires minimal scheduled maintenance or lubrication, although it is recommended that an annual inspection is performed to ensure that critical components are not suffering from excessive wear or corrosion.

The generator and pitch bearings are sealed and "lubricated for life" hence require no re-greasing.

The following torque setting should be used when checking fastener tightness

	Torque (Nm)
M8	18
M10	35
M12	70
M16	320

Blades

Before lowering the wind turbine, observe the rotor at high speed looking for signs of imbalance. Any unusual noises could also indicate blade problems and should be investigated further.

After lowering the turbine:

- Check for any damage or cracks to the leading edge .
- Check for cracks in the blade structure, particularly near the blade root. If any damage is noticed which is greater than surface cracking then the blades will need replacing.
- Check blade bolts for tightness and corrosion. The blade bracket bolts should be 80Nm

Pitch Mechanism

The pitch mechanism needs a visual inspection at all services. It is important that all fasteners are checked for tightness and that there is no damage on any component.

The springs need replacing every five years to ensure continued operation.

Nacelle

Before lowering the turbine check that the manual pitch mechanism operates satisfactorily.

After lowering the turbine:

- Check for any twist or damage in the power cable.
- Check for free rotation about the yaw bearing. The check the grease on the yaw bearing and if regreasing is required use a high quality, high temperature grease such as Mobil XHP 222 for lubrication.
- Check the condition of the pitching cable.
- Check the entire machine for damage

General

- Check the paint condition and touch up if necessary.
- Check all turbine fasteners for fit and condition
- Check all tower fasteners for fit and condition.
- Check the condition of all wiring connections.
- The access cover on the nacelle should be removed to allow inspection of the slip rings and brushes.

Appendix 1 – Tool List

- Grease gun and a high quality, high temperature grease such as Mobil XHP 222 or equivalent. (Maintenance Only)
- Cable installation rods (15m minimum)
- Hydraulic Torque Wrench (up to 2000Nm) or Torque Wrench and Multiplier
- M30 Wrench
- M36 Wrench
- 12” Adjustable Wrench
- Certified lifting slings. Rated at 3T
- Lump Hammer
- Digital Spirit Level with 0.1 degree minimum accuracy
- M30, M36, M42 Sockets
- Electricians Tool Kit
- Mechanical Tool kit
- Metric Socket Set
- Torque Wrench
- Set of flexible headed spanners
- 1 Tonne Chain Block
- 3 x 3 Tonne Shackels
- Theodolite for ensuring tower level
- Axel stands or other support for wind turbine blades

Appendix 2 – Troubleshooting Guide

Fault	Analysis
Blade do not turn or turn slowly	Blades incorrectly installed. Manual pitch mechanism activated Short-circuit brake applied Electrical short circuit or electrical circuit leads to the control system of short-circuit; Power curve not programmed in inverters
Noise from turbine head	Nacelle cover and nose cone are not installed correctly and are interfering as the turbine turns The head connectors (bolts, nuts, etc.) are loose
Severe head shaking in low winds	Blades, blade mounting plate, blade shaft or tower bolts are loose
Tower movement	Blades, blade mounting plate, blade shaft or tower bolts are loose Nose or blade damage
No power	Control at a no-load state; Wires and circuit board failure;

Appendix 3 – Inverter Display Message and Settings

Display Message	Description
Generating	Generating electricity
Low wind	Wind is low and the input voltage does no reach the lowest point of the inverter input voltage range
Initializing	Inverter is initializing
OV-G-V	Grid voltage is over inverter grid voltage range
UN-G-V	Grid voltage is under inverter grid voltage range
OV-G-F	Grid frequency is over inverter grid frequency range
UN-G-F	Grid frequency is under inverter grid frequency range
G-IMP	Grid impedance high
NO-G	No grid connected
OV-DC	DC voltage is over inverter input voltage range
OV-BUS	Over DC bus voltage
UNB_BUS	DC bus voltage unbalance
UN_BUS	Under DC bus voltage
UNB2_BUS	DC bus voltage unbalance (transient)
SHORT-PRO	Short circuit fault
INI-PRO	System initial fault
TEM-PRO	Over Temperature
GROUND-PRO	Ground fault

The inverters should arrive preprogrammed. If this is not the case the following power curve parameters should be added using the inverter programming manual

DC value (V)	Power (W)	DC value (V)	Power (W)
30	0	230	490
40	0	240	580
50	0	250	660
60	0	260	750
70	0	270	830
80	0	280	920
90	0	290	1000
100	0	300	1090
110	0	320	1260
120	0	340	1430
130	0	360	1620
140	0	380	1750
150	0	400	1850
160	0	420	1930
170	0	440	2000
180	70	460	2000
190	150	480	2000
200	240	500	2000
210	320	520	2000
220	410	540	2000

Appendix 5 – Foundation Sign Off Certificate

Osiris Foundation Sign Off Certificate

I CERTIFY THAT THE FOUNDATIONS FOR THE WIND TURBINE AND TOWER (TO BE INSTALLED AT THE ADDRESS BELOW) ARE INSTALLED AT LEAST THE STANDARDS OUTLINED IN THE OSIRIS INSTALLATION INSTRUCTIONS.

WHERE CHANGES TO THE SPECIFICATION HAVE BEEN MADE THESE HAVE BEEN MADE WITH THE APPROVAL OF A REGISTERED CIVIL ENGINEER AND THESE CHANGES DO NOT REDUCE THE FOUNDATIONS RATINGS IN ANY WAY. WE ALSO HOLD AN APPROPRIATE DESIGN FILE SHOWING ALL CALCULATIONS MADE AND THIS IS AVAILABLE ON REQUEST.

I UNDERSTAND THAT ANY DEVIATIONS FROM THE GINLONG SPECIFICATION WHICH ARE JUDGED TO REDUCE THE EFFECTIVNESS OF THE FOUNDATION DESIGN MAY INVALIDATE OUR WARRANTY

IF THE FOUNDATION IS FOUND TO BE INCORRECT THEN I ALSO UNDERSTAND THAT I MAY BE CHARGED FOR ADDITIONAL WORK REQUIRED IN BRINGING THE FOUNDATIONS TO A SUITABLE SPECIFICATION TO ALLOW FOR TURBINE INSTALLATION

NAME:	
SITE ADDRESS:	
DATE:	
SIGNED	

Appendix 6 – Installation Checklist

Turbine Siting	
Is the turbine generally in a safe location? (e.g. without hazard to nearby buildings and structures)	
Is there a safe distance (3m) for exposed moving parts?	
Are foundations, support structure etc as per our foundation pack?	
Are all turbine support structure fixings secure?	
Is turbine support structure protected against climbing?	
Is lowering equipment suitably stored?	
Turbine Installation	
Is wind turbine installed to the requirements in this manual?	
Is turbine brake system working?	
Has brake system been explained to customer?	
Are turbine speed and vibration levels acceptable?	
Cables	
Are turbine electrical connections sound and weatherproof?	
Is cable properly laid and sufficient distance from heat sources/ sharp surfaces/edges?	
Is cable as our recommendations?	
Turbine isolator	
Is the isolator correctly rated?	
Is the isolator installed correctly and all electrical connections secure?	
Are isolator labels in place?	
Turbine junction box	
Is the junction box installed correctly and electrical connections secure?	
Is the junction box in a suitable location?	
Are labels in place?	
Earthing	
Is the turbine structure earth correctly installed?	
Inverters	
Are the inverters correctly programmed?	
Has disconnection on grid failure been checked?	
Turbine Metering	
Is the metering installed correctly and are all electrical connections secure?	
Has the metering system been explained to the customer?	
Turbine Controller	
Is the controller installed correctly and all electrical connections secure?	
Is the controller suitable mounted and adequately ventilated?	
Are appropriate labels in place?	
Wiring	
Is AC cable suitably specified in accordance with BS7671?	
Is cabling suitable routed and secured?	
Are dual supply notices installed at the service termination, meter position and all points of isolation?	

Is suitable AC fault current protection provided at the distribution board?	
Is the point of AC isolation suitably labelled?	
Documentation	
Has an Operation & Maintenance manual been supplied including problem diagnostics, contact details, maintenance schedule/record sheet, etc?	
Have manuals for all specific equipment been passed to the customer?	
Has all warranty information been passed to the customer?	
Has information on system design been supplied to the customer eg. electrical schematics, civil works drawings, cable calculations etc?	
Has the installation certificate & test sheet (BS7671) been supplied to customer?	
Has signed approval from DNO been passed to the customer?	
Is the system schematic suitable displayed?	
Are the protection settings and installers contact details suitable displayed?	
Post-Installation Checklist	
BS7671 certification to building control or Part P body?	
Commissioning Confirmation to DNO?	
Completion of Works Certificate to Customer?	
Signed: Name:	

Appendix 7 – Installation Sign Off Sheet

Osiris 10 Installation Certificate

ACCREDITED INSTALLER COMPANY		
COMMSSIONING ENGINEERS NAME		
INSTALLER EMERGENCY CONTACT DETAILS:		
MSC ACCREDITATION NUMBER		
TURBINE MODEL	OSIRIS 1.6	
	OSIRIS 10	
TURBINE SERIAL NUMBER		
GENERATOR SERIAL NUMBER		
TOWER TYPE		
CUSTOMER NAME		
INSTALLATION ADDRESS		
FURTHER NOTES:		

I CERTIFY THAT THE ABOVE TURBINE WAS INSTALLED IN ACCORDANCE WITH THE INSTALLATION INSTRUCTIONS, THAT ALL REQUIRED DOCUMENTS AND CERTIFICATES HAVE BEEN PASSED TO THE CUSTOMER AND THAT THE SYSTEM OPERATION AND SHUTDOWN PROCEDURES HAVE BEEN EXPLAINED IN DETAIL.

SIGNED:

DATE:

Appendix 7 – Maintenance / Service Log

MAINTENANCE / SERVICE LOG

DATE	DESCRIPTION OF WORK, PROBLEMS IDENTIFIED AND PARTS REPLACED	CERTIFIED SERVICE ENGINEER

Appendix 8 – Service Report Sheet

CUSTOMER NAME:		TURBINE MODEL	
SITE ADDRESS		TOWER TYPE	
		INSTALL DATE	
ORDER NO		S/N	
SERVICE TYPE		UNDER WARRANTY?	

G= GREEN PASS, A= AMBER PASS - FURTHER WORK MAY BE REQUIRED IN THE FUTURE, R= RED FAIL - FURTHER WORK REQ'D

	CHECKED?	CODE
TOWER AND FOUNDATION		
GENERAL CONDITION		
BOLT TORQUE		
TOWER WELDS		
HYDRAULIC FIXINGS		
MANUAL PITCH MECHANISM		
LIFT CYLINDER		
GENERAL CONDITION		
NACELLE		
MAIN COVER CONDITION		
NOSE CONE COVER		
YAW BEARING LUBE		
BOLT TORQUE		
ROTOR		
PITCH MECHANSIM		
BLADE FIXINGS		
PITCH OPERATION		
FIXINGS		
WELD INSPECTION		
BEARING LUBRICATION		
PITCH SPRINGS		
BLADES		
BOLT TORQUE		
BLADE CONDITION		

	CHECKED?	CODE
ELECTRICAL SYSTEM		
CONTROLLER OPERATION		
CABLE CONNECTIONS		
CABLE CONDITION		
INVERTER CONNECTION		
INVERTER OPERATION		
ADDITIONAL WORK		
NOTES		

	SIGNED	NAME	DATE
SERVICE ENGINEER			
CUSTOMER			